

Technologies for MicroCHP

Dr. Thomas A. Butcher
Brookhaven National Laboratory

National Micro-CHP Technology
Pathways Workshop
June 11, 2003

Technologies

- PEM Fuel Cells
- Solid Oxide Fuel Cells
- Reciprocating Engines
- Stirling Engines
- Rankine / LIC Cycles
- Thermoelectrics
- Thermophotovoltaics

Example – Solid Oxide FC - Hexis



Source: Sulzer-Hexis

Example – Solid Oxide FC - Hexis

HXS 1000 Premier

Output: 1 kW electric

2.5 kW thermal (8500 BTU/hr)

Auxiliary burner as needed

Fuel natural gas / steam reformer (oil under development)

Base loaded during heating season

Completed 90,000 hour / 6 unit field test in 2001

Target 400 installed units by the end of 2003

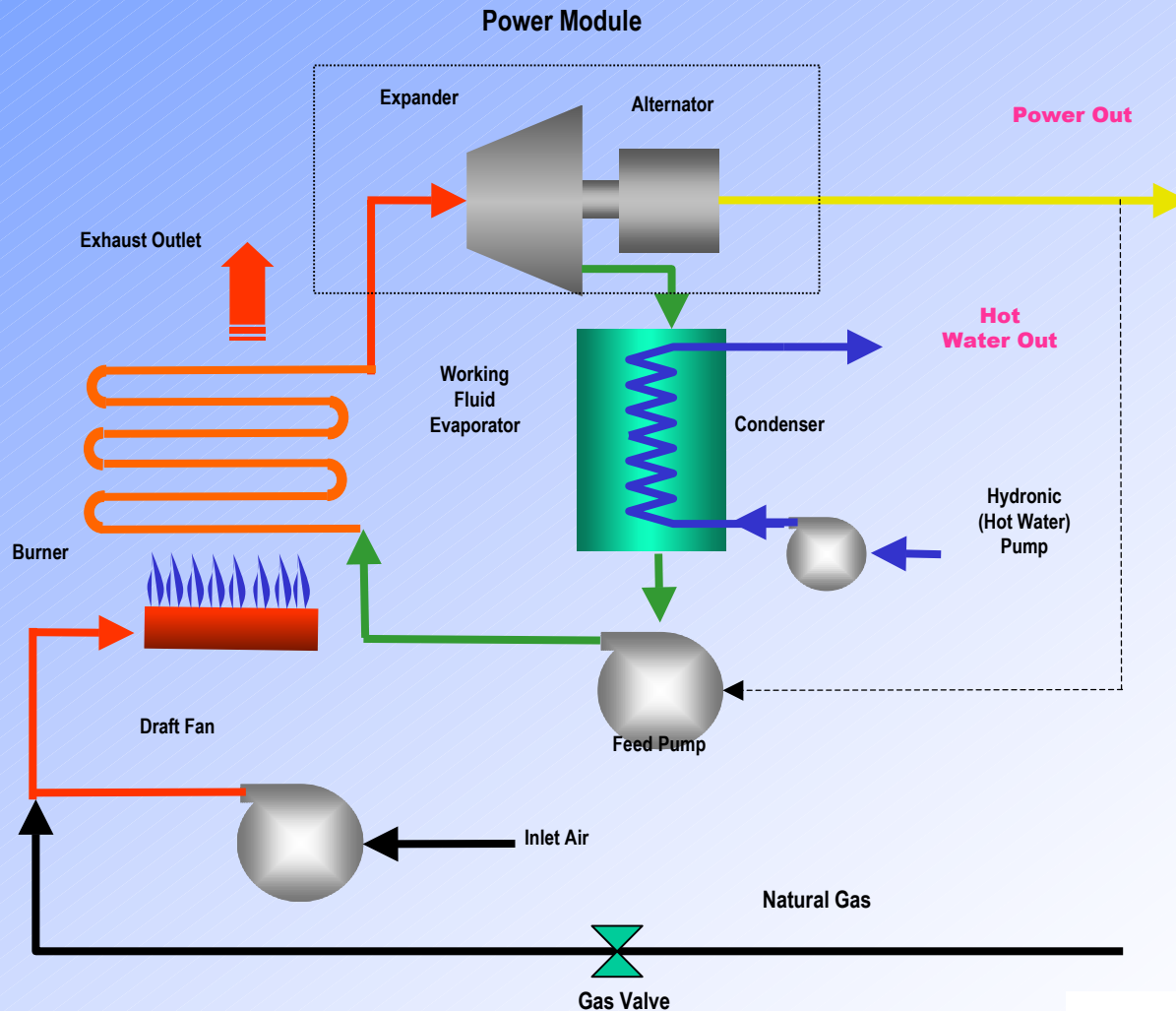
Utilities as owners / operators

Example – Solid Oxide FC - Hexis



Source: Sulzer-Hexis

Example: Organic Cycle – Inergen System



Source: Battelle Columbus Laboratory

Example: Organic Cycle – Inergen System

Output : 2.5 kW Electric @ full load

33 kW thermal 113,000 BTU/hr

T/E = 13.2

Easy grid connection

90%+ overall efficiency

Heat – led

Minimal export of power

Gas-fired, other fuels possible

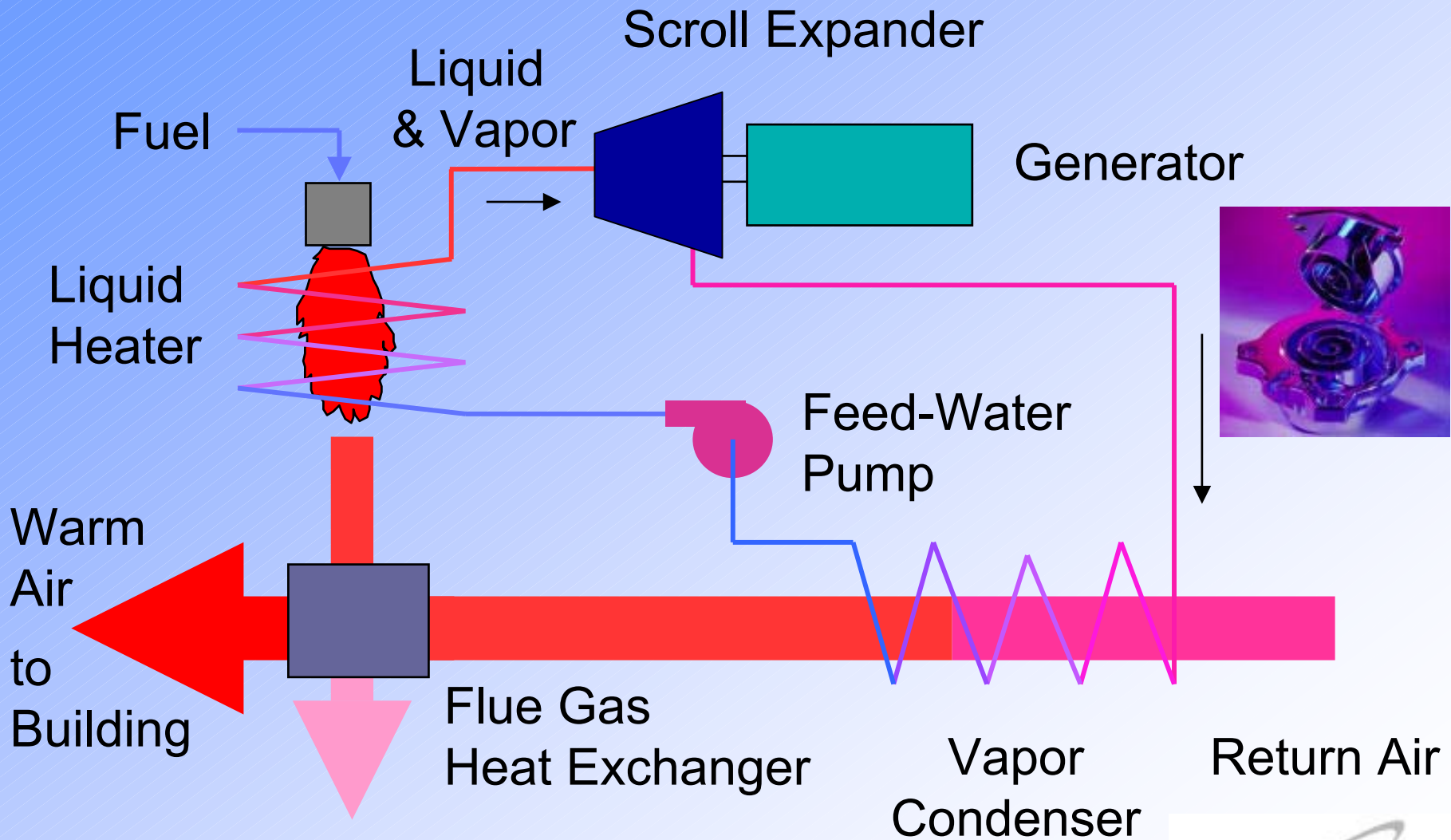
Energetix microPower Limited – 1/03

Example: Organic Cycle – Inergen System



Source: Battelle Columbus Laboratory

Example: Liquid Injected – Climate Energy



Example: Liquid Injected – Climate Energy

Oil-free, high efficiency scroll expander

Minimal quantity of water in cycle

Commonly available components

No valves

Range of Products Planned

1-10 kW

Warm Air and Hydronic

T/E = 8.5

Fuel – gas but flexible

Very Active Development

Example: Liquid Injected – Climate Energy

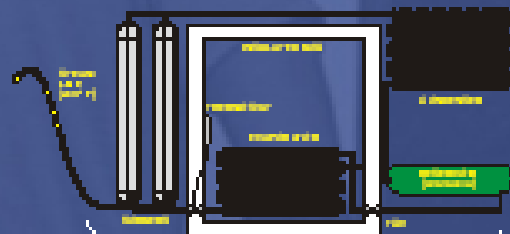


Planned integration with a warm air furnace – a unique North American innovation

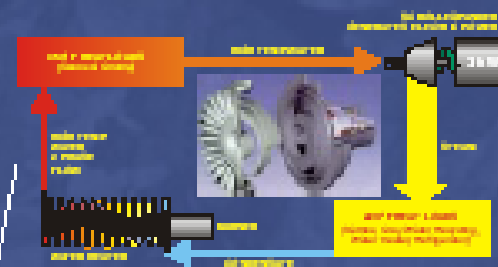


Military application -Climate Energy

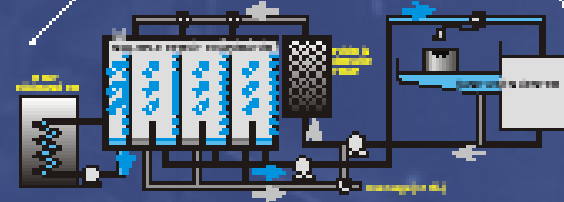
Heat-Driven Refrigerator Safely Stores Perishable Foods Without Electric Power



Cogenerator: Efficiently Generates Heat and Electric Power



8x10 Foot Expandable ISO Container (Expands to 24x10 Feet)



Gray Water Recycling System Reduces Water Consumption by 75%

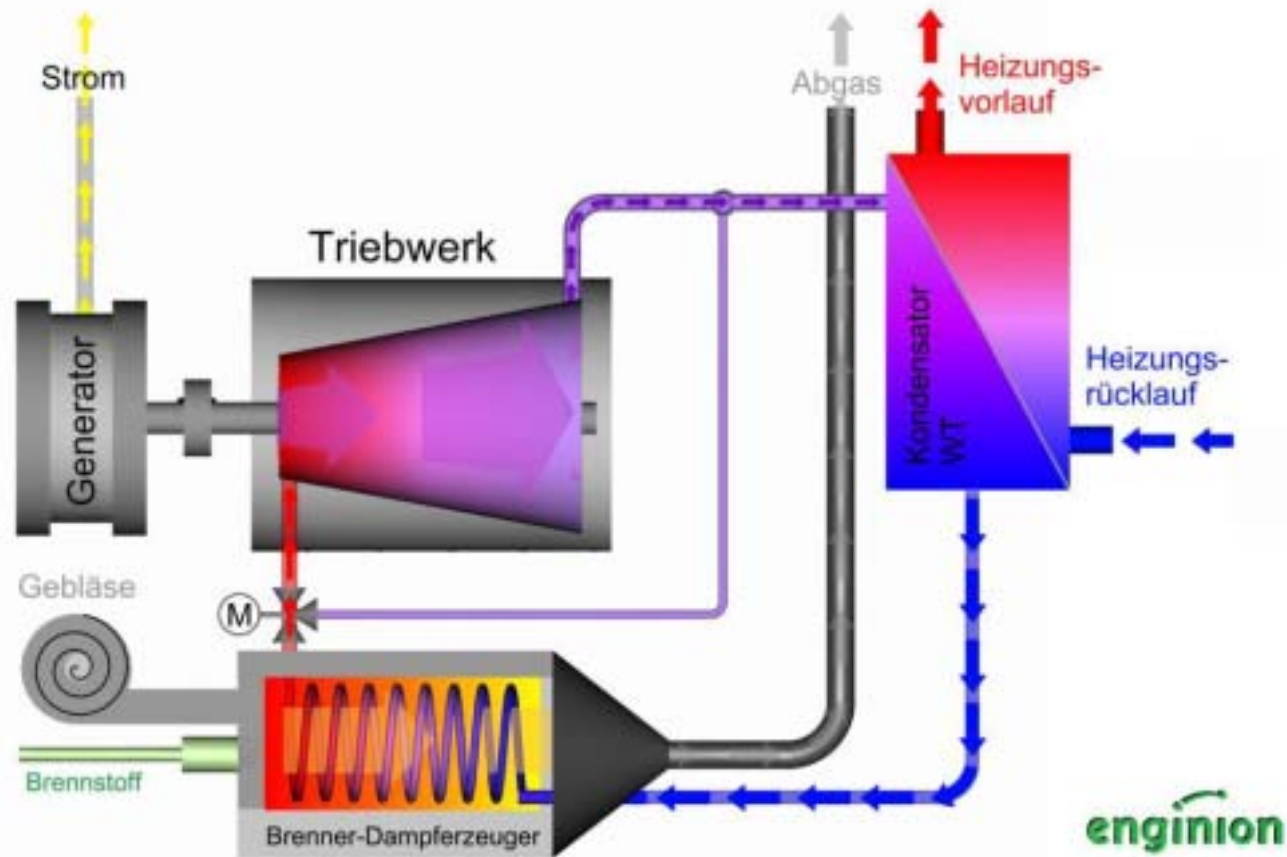


High Capacity Commercial Appliances Increase Meal Output with Reduced Labor

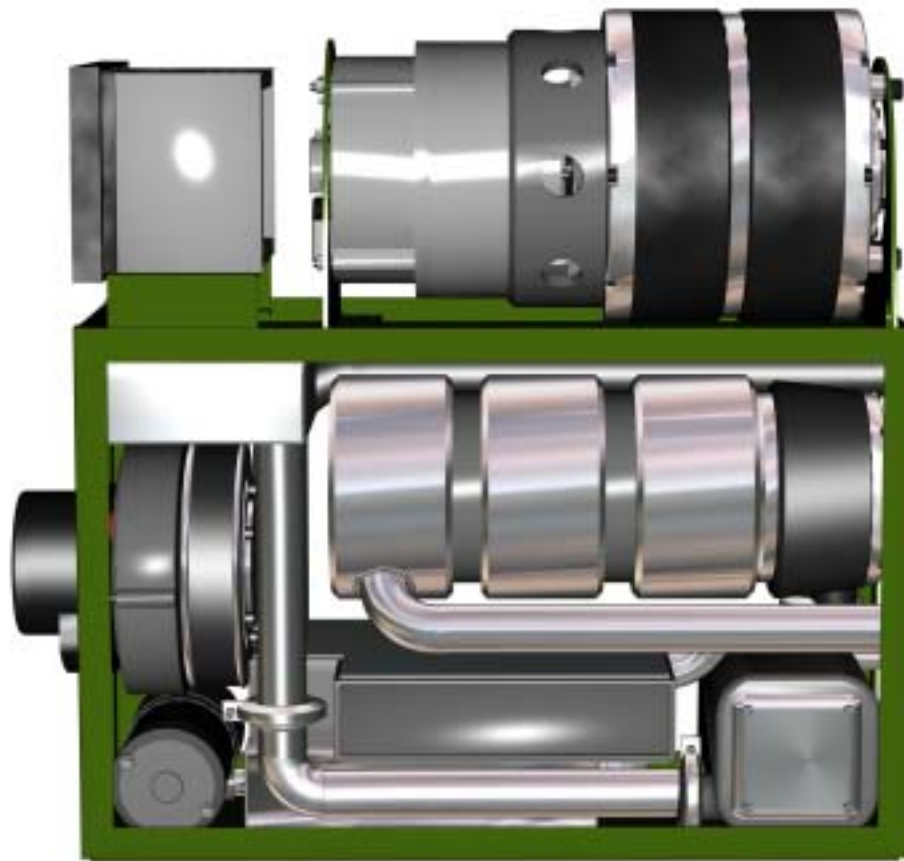
Example – Enginion

SteamCell

Funktions-Schema



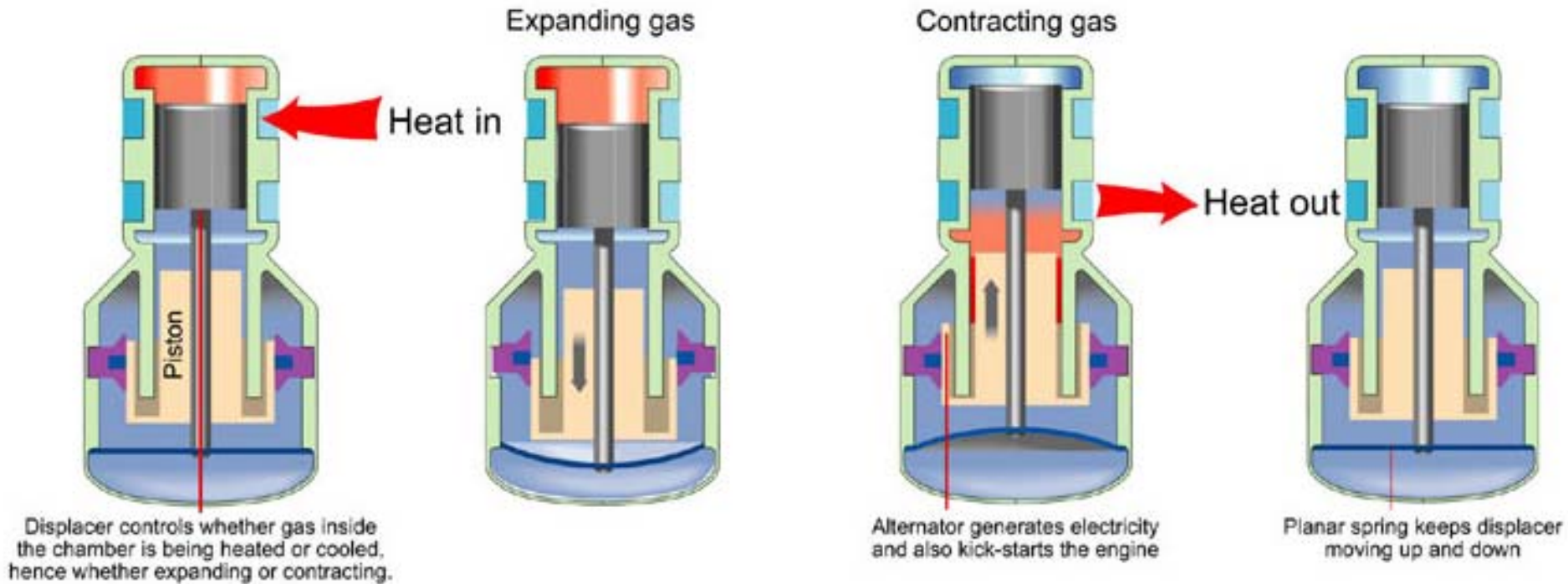
Example – Enginion



Example - Enginjon



Example: Stirling Engine - Microgen



Source: Microgen

Example: Stirling Engine – Microgen

Output: 1.1 kW Electric

To 38 kW Thermal (130,000 BTU/hr)

Condensing Boiler

Overall Efficiency +90%

+ \$30 million investment to date

Dedicated test facility, 48 units – 24/7

2004 Market Launch - BG Group / Microgen

Fuel – gas, but flexible

Source: Microgen

Example: Stirling Engine – Microgen



Source: Microgen

Example: Stirling Engine – Microgen



Thermoelectric Power Generation

- Pairs of dissimilar conductors generate power
- Many pairs “stacked” to achieve reasonable power levels
- T/E – 20
- Fuel flexible, quiet, no moving parts
- Being applied to self-powered appliances

Reference: [www . Hi-z.com](http://www.Hi-z.com)

Thermophotovoltaic Power Generation

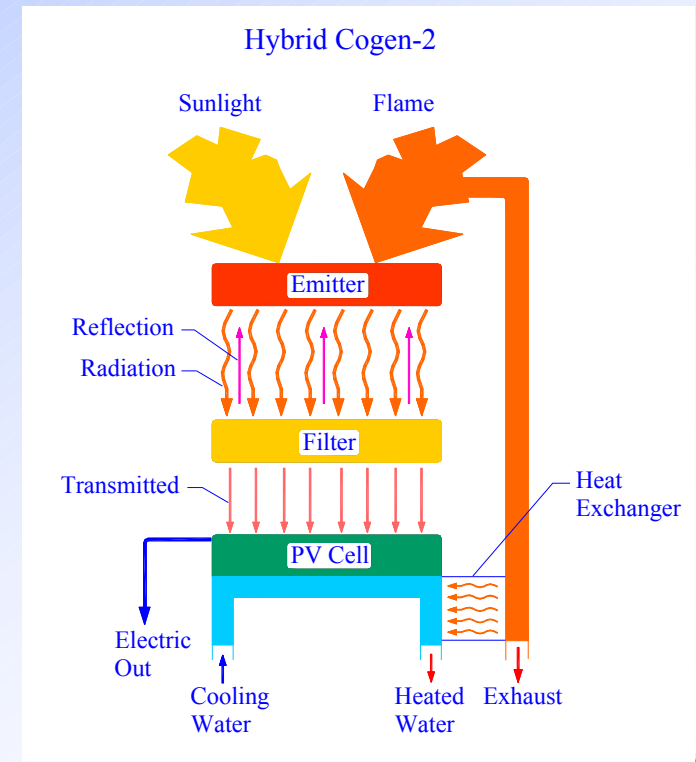
- Ceramic, heated by flame, emits light which generates electric power via photocell
- Matching of light wavelength range to cells critical for high performance
- Under development for military applications



Reference: [www . Pueffer.de/TPV/tpv.html](http://www.Pueffer.de/TPV/tpv.html)
[www . Thermopv.org/TPV5-2-51-Horne.pdf](http://www.Thermopv.org/TPV5-2-51-Horne.pdf)

Edtek Hybrid Solar/Fossil System

- GaSb concentrating TPV cells co-generate electricity (15% eff) and process grade hot water (51%)
- Receiver overcomes the economic barriers common to renewables by means of a unique concentrator design that achieves a high concentration ratio (1000:1)
- Secondary revenue stream from the co-generated hot water produced simultaneously with the electric power.
- Operates on Solar and/or fossil fuel for 24-hour power generation to eliminate expensive batteries.



Edtek System Specifications

Dish diameter	56 inches
Dish collection aperture	17.1 sq. ft.
Maximum energy intercepted	1700 watts
Electricity Produced	500 watts *
Hot water produced	100 to 130 gal. /day @ 150F
Reflector	Glass protected silver
Collection efficiency	91%
Primary concentration ratio	800:1
Tracking	2 - Axis
Tracking Accuracy	+/- 0.2 degrees
Control	On-board Computer
Night and weather protection	Ground facing stowage
Wind Protection	Releases to turn edge-on

* Solar is augmented with fossil fuel in hybrid system



Issues for microCHP

- Early systems need to be reliable
- The economics need to be there and homeowner needs to be convinced of savings.
- System and interconnect standards needed
- New supply model may be needed

Technologies - when?

- PEM Fuel Cells - 2010?
- Solid Oxide Fuel Cells - 2005?
- Stirling Engines – 2004?
- Rankine Cycles – 2005?
- Thermoelectrics – self powered
- Thermophotovoltaics – in progress

Unique U.S. Considerations

- Warm air furnaces
- Higher value for stand-alone operation
- Higher power level may be needed
- Noise and Size are less critical

Conclusions

- microCHP technologies are receiving a great deal of commercial and technical attention at present.
- This technology offers the potential for a dramatic improvement in the efficiency with which energy resources are use.
- A new model for home “heating” appliance configuration, ownership, and service may be needed.